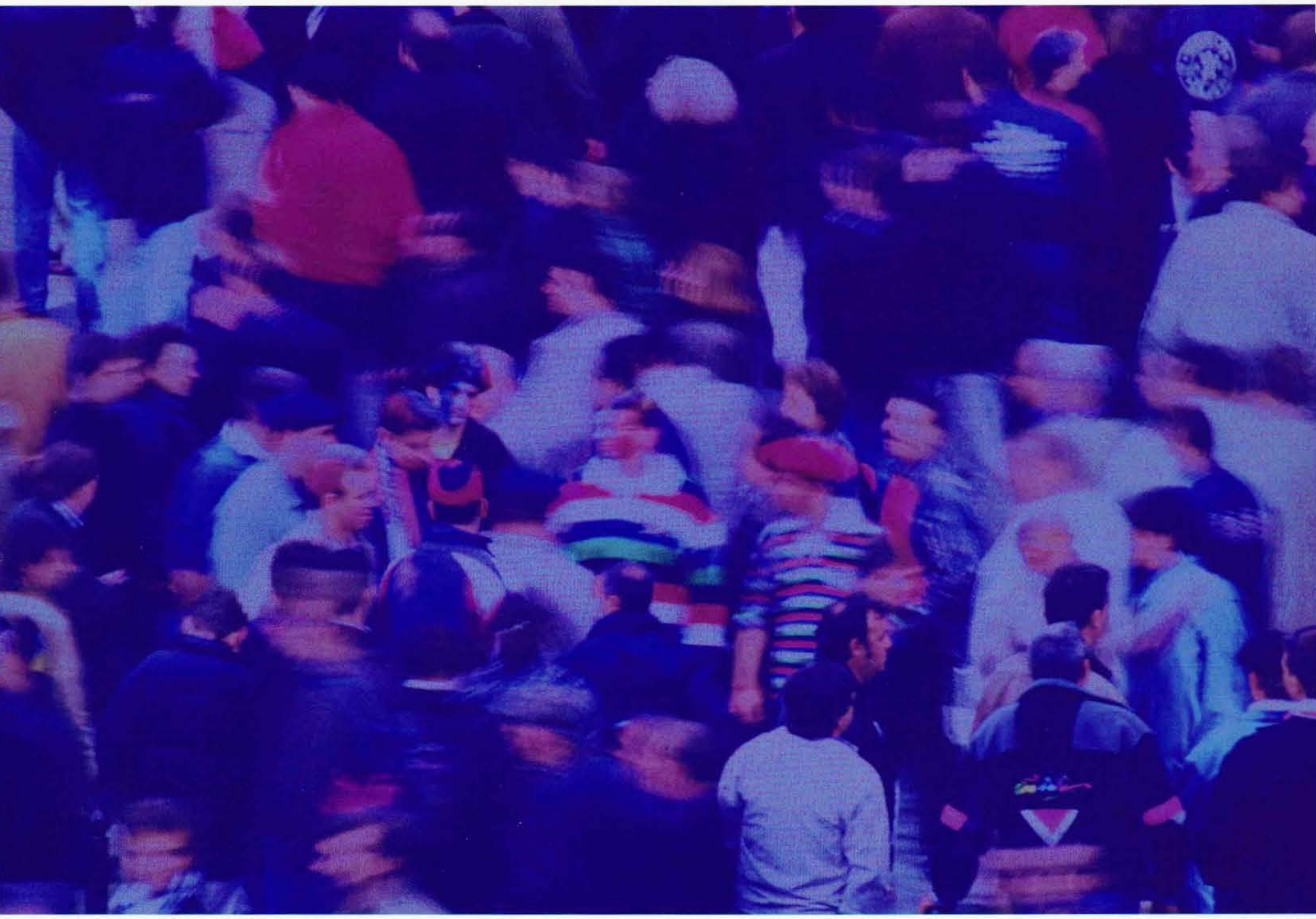


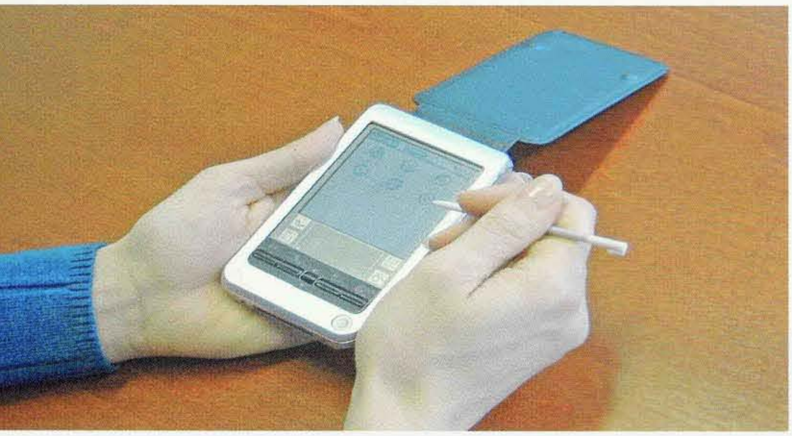
European Mobile Integrated Location System

EMILY

Location-Based Services

In this age of significant telecommunications competition, mobile network operators are continuously looking for competitive and innovative ways to create differentiation and to increase profits.

One of the best ways to accomplish this is through the delivery of highly personalised services, and one of the most powerful ways to personalise mobile services is with Location-Based Services (LBS). Examples of LBS include emergency and assistance services, in-vehicle and pedestrian navigation and fleet management, but also pull services such as finding a restaurant, shop or the nearest service provider according to the customer's need.



LBS Positioning Technology

Satellite-based positioning — one of the most popular positioning technologies behind LBS — relies upon the Global Positioning System (GPS). However, there are other means of positioning in addition to GPS, including network-based positioning technologies that rely on various means of triangulation of the signal from cell sites serving a mobile phone.

Market studies show that user expectations in terms of location technology performance are not being met by currently available solutions.

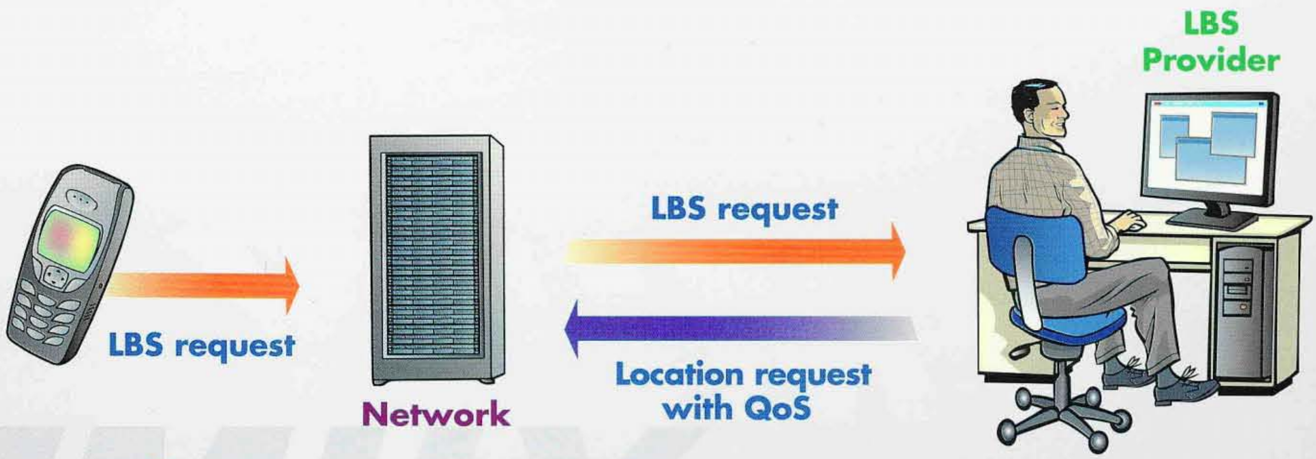
In general terms, satellite positioning provides the requested accuracy, but comes short in terms of availability and response time, depending on a number of conditions. Cellular positioning offers good availability and response time, and is generally complementary to satellite positioning — but it does not always fulfil the accuracy requirements.

EMILY System

Taking into account the attractiveness of Location-Based Services for mobile telecommunication operators in Europe and the complementary features of terrestrial and satellite positioning technologies, the EC-supported EMILY project's scope was to specify, develop and test an innovative, high performance positioning technology which exploits terrestrial and satellite location data.

In addition, the EMILY solution comprises a network component dedicated to minimise the cost of the location process within the requested quality of service, allowing the choice of the best-suited available technologies.

EMILY has also developed and tested the highly innovative Auto-LMU (Location Mobile Units) concept.



step 1

EMILY Technology

EMILY is an advanced location system for mobile devices with or without hybridisation capabilities. It is designed to optimise the location process according to a number of parameters — including the requested Quality of Service (QoS), the mobile terminal capabilities, the network location capabilities and available technology.

The EMILY system is composed of the following main elements:

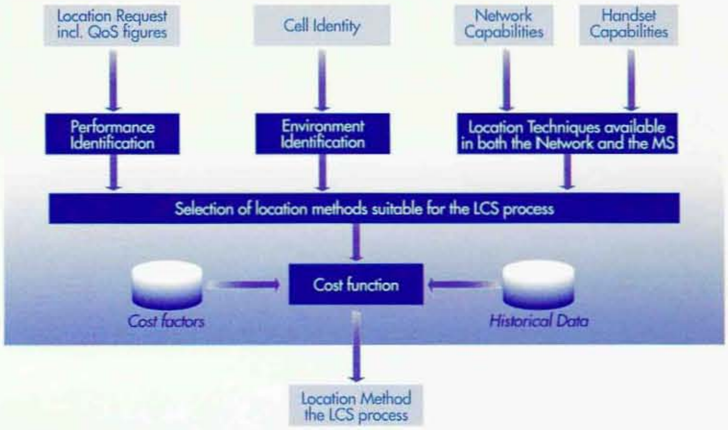
1. An enhanced Mobile Station

The Mobile Station (MS) prototype implemented in the project consists of a GSM/GPRS handset — a G83 of Dai Telecom — modified to enable a cable serial connection with a GPS/EGNOS unit of U-Blox. The modifications allow the following features:

- The extraction of location information NMR and Observed-Time-Difference (OTD) from the terrestrial cellular network
- The exchange of this information with the GPS module, where the positioning calculating function — and in particular the hybridisation algorithm — is performed
- The exchange of information between the SMLC and the MS (such as Assistance Data) via an IP over GPRS protocol
- The synchronisation of the terrestrial GSM network clocks

2. The Smart Layer

The Smart Layer, a Capgemini software component in the SMLC (Serving Mobile Location Centre), is the entity having the intelligence to decide which positioning technique (Cell-Id, NMR, E-OTD, AGPS) or hybridisation of techniques will be used for the calculation of the position. The selection or the combination of techniques is based on the Quality of Service requested by the application, the cost function (traffic load, consumption of each positioning method) and the network/mobile capability.



3. The Hybridisation Algorithm

The EMILY hybridisation algorithm is a signal processing procedure designed for extracting relevant information from measurements of time-difference-of-arrival (TDOA) of the signals arriving to a mobile station. These signals may consist of pairs of base station signals, pairs of satellite signals and (optionally) hybrid pairs. The method performs two main tasks:

1. It uses statistical information retrieved from the signals to identify those having excessive propagation path due to the presence of non-line-of-sight from base station-to-mobile or satellite-to-mobile propagation. If a wrong signal is identified, it is discarded from the position computation function, thus improving the mobile positioning accuracy.
2. It combines the available signals and measurements in a weighed manner, automatically employing the most weight to the most precise measurements, and adaptively to environment changes.

Testing and Validation

Following the user LBS request, the LBS provider submits a Location Request with a Quality of Service (QoS) to the network (step 1). The Smart Layer computes the location strategy taking into account the requested QoS, the user mobile location capabilities as well as network location capabilities and available technologies. The network sends a pre-location request to the user mobile and receives a pre-location response (NMR calculation) (step 2).

The network checks whether the pre-location response matches the selected location strategy. If yes, it transfers the pre-location response to the LBS provider. If it doesn't match, the network sends a Location Request to the mobile together with the Assistance Data. The mobile makes the hybridisation (AGPS + EOTD) and sends the location response and the Auto-LMU data (OTD) back to the network. The location response is then transmitted to the LBS provider (step 3).

The EMILY test phase took place in Paris, using the Bouygues Telecom test-bed in different urban indoor/outdoor environments, and looked at the following requirements:

- Availability, as a percentage of mobile network coverage
- Accuracy
- Time to Response
- Frequency of location

Table 1 shows the test results.

The Smart Layer tests show the optimisation of the obtained positioning process.

Table 2 illustrates the choice of Smart Layer in different test environments.

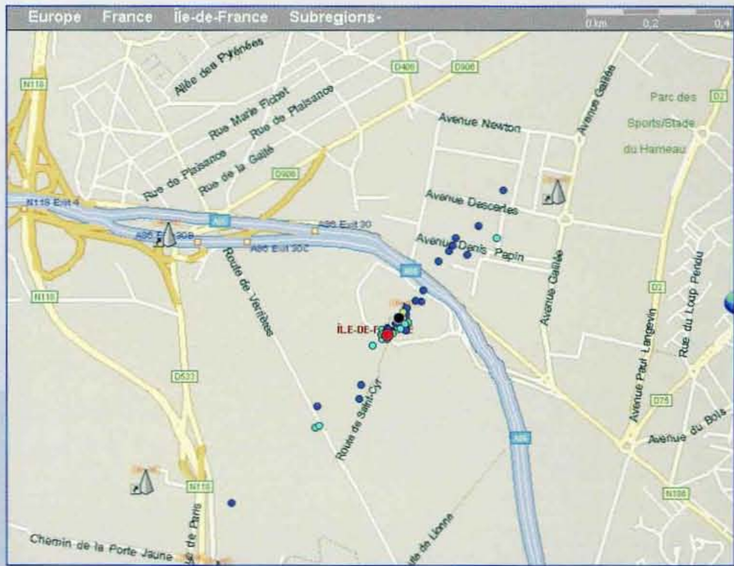
Table 1 EMILY test synthesis

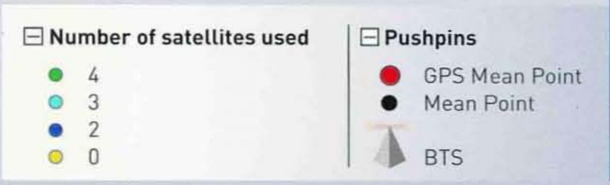
EMILY test synthesis	Dense urban outdoor	Dense urban indoor	Urban outdoor (open sky)	Urban blocked outdoor	Urban deep indoor	Urban medium indoor
Availability	100%	100%	100%	100%	100%	100%
Accuracy	46 m	74 m	3 m	62 m	110 m	50 m
Time to response	9 seconds	23 seconds	11 seconds	26.5 sec.	39 seconds	27 seconds
Frequency of location	1 req every 9 seconds	1 req every 23 seconds	1 req every 11 seconds	1 req every 26 seconds	1 req every 39 seconds	1 req every 27 seconds

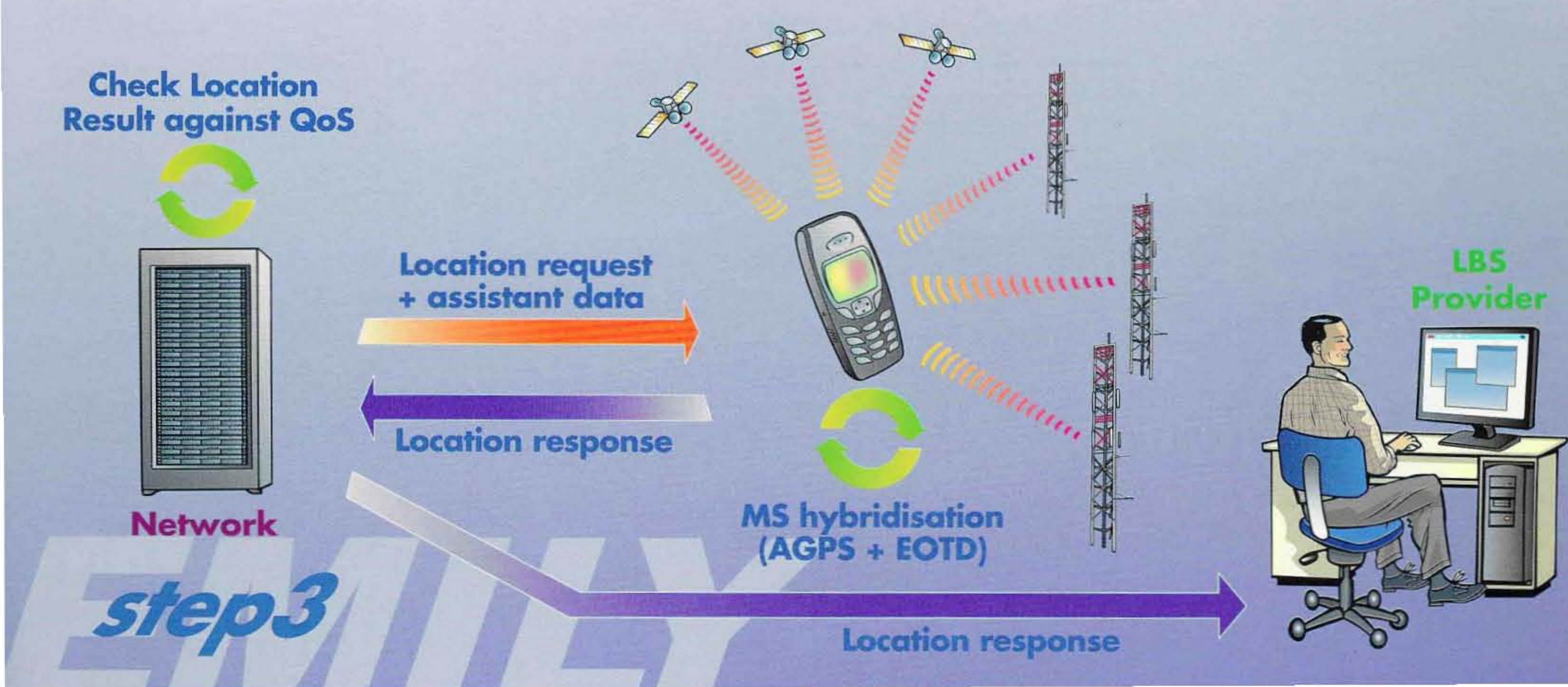
Table 2 Smart Layer chosen technique

EMILY test synthesis	Method
Dense urban outdoor	AGPS
Dense urban indoor	AGPS + EOTD + NMR
Urban outdoor	AGPS
Urban blocked outdoor	AGPS + EOTD + NMR
Urban deep indoor	NMR
Urban medium indoor	AGPS + EOTD + NMR

Urban Blocked Outdoor Test Results







The Auto-LMU Innovative Concept

The Auto-LMU function developed in EMILY is a signal processing procedure for computing the reference time of those signals received from base-stations that are non-synchronous with a common clock.

Non-synchronous signals cannot be used for the position computation when using conventional methods. The classical solution, used for example in E-OTD, is to deploy fixed LMU's for the computation of the reference time, which results in very expensive network deployment.

The Auto-LMU method is capable of using non-synchronous signals thanks to its capacity of simultaneously processing hybrid measurements from both base-stations and satellites. Moreover, the necessary time reference retrieved by a mobile station can also be shared with other mobiles through the network, thus improving the overall system availability.

The Auto-LMU method allows comparable results with the classical LMU deployment strategy to be obtained, but with much lower investment costs for the operator by using the "cooperative" behaviour of mobile stations — a "peer-to-peer approach" to synchronisation issues in cellular positioning!

The best demonstration of Auto-LMU happened during moving pedestrian trials, which best showed the adaptive behaviour of EMILY. Tests consisted of an outdoor scenario, where at least four to six satellites were available, and an indoor scenario, where less than three satellites were available. When outdoors the MS used AGPS to position and produce RTD (Relative Time Difference), which were also uploaded to the network. Once indoors the MS was able to position using the hybridisation of satellites and cellular measurements thanks to the previously stored RTD.

Glossary

LBS	Location Based Services
GPS	Global Positioning System
LMU	Location Mobile Units
QoS	Quality of Service
MS	Mobile Station
NMR	Network Measurements Report
OTD	Observed Time Difference
SMLC	Serving Mobile Location Centre
IP	Internet Protocol
E-OTD	Enhanced Observed Time Difference
A-GPS	Assisted GPS
TDOA	Time Difference Of Arrival

EMILY - the way forward

EMILY realised and extensively field-tested:

1. A prototype of an innovative hybridisation technique of satellite and cellular positioning signals.
2. The auto-LMU concept and function (patent pending), relieving the E-OTD solution from its main drawback, which relates to its deployment costs.
3. An intelligent network component called Smart Layer (patent pending), optimising the location process on the basis of a parametric cost function.
4. An efficient A-GPS solution based on a User Plane implementation, anticipating the current trends in the OMA and 3GPP.

Thanks to these developments, EMILY allows cellular operators and service providers to offer Location-Based Services relying on an efficient, high-performance positioning technology. This will require an upgrade in the operator's SMLC and the availability of EMILY-enabled mobile terminals consisting of a GPS/Galileo receiver and a software component integrated in the mobile.

In the short term, the EMILY's key benefits are in two main applications: fleet management and goods tracking for the corporate market and emergency calls for the mass market. Fleet management and goods tracking are applications in which the form of the mobile terminal is less important compared to the advantages that better positioning performance can bring. Corporate users value these advantages in terms of reduced operational costs and are ready to justify their costs when the return on their investment is positive. In the short and medium term, this represents an opportunity for EMILY, as it does not require large investment in mobile station integration or the commitment of major handset manufactures.

Emergency call application stakeholders have shown a particular interest in EMILY for two main reasons. The first being that the improved performance of the positioning technology can have a large impact on the effectiveness of the emergency response. Second, EMILY provides for intrinsic redundancy of the positioning technology, ensuring a position is retrieved almost 100% of the time.

For further information about EMILY please contact:

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Project Consortium

ERTICO (coordinator) • Bouygues Telecom • Capgemini • Dai Telecom S.p.A • Ublox • UPC

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